

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
14 October 2004 (14.10.2004)

PCT

(10) International Publication Number  
**WO 2004/087718 A1**

(51) International Patent Classification<sup>7</sup>: C07F 7/18,  
C07D 471/14

TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,  
ZW.

(21) International Application Number:  
PCT/EP2004/050414

(22) International Filing Date: 1 April 2004 (01.04.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
03007663.2 3 April 2003 (03.04.2003) EP

(71) Applicant (for all designated States except US): ALTANA  
PHARMA AG [DE/DE]; Byk-Gulden-Str. 2, 78467 Kon-  
stanz (DE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): ALSTERS, Paulus  
Lambertus [NL/NL]; Oranjeplein 273, NL-6224 KZ  
Maastricht (NL). MINK, Daniel [DE/BE]; Heckenweg 5,  
B-4700 Eupen (BE).

(74) Agent: RUPP, Herbert; Altana Pharma AG, Byk-Gulden-  
Str. 2, 78467 Konstanz (DE).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,  
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,  
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,  
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,  
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,

(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), Euro-  
pean (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,  
GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted  
a patent (Rule 4.17(ii)) for the following designations AE,  
AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ,  
CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE,  
EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS,  
JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA,  
MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM,  
PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ,  
TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM,  
ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD,  
SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY,  
KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG,  
CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT,  
LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF,  
BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN,  
TD, TG)
- of inventorship (Rule 4.17(iv)) for US only

**Published:**

- with international search report
- before the expiration of the time limit for amending the  
claims and to be republished in the event of receipt of  
amendments

For two-letter codes and other abbreviations, refer to the "Guid-  
ance Notes on Codes and Abbreviations" appearing at the begin-  
ning of each regular issue of the PCT Gazette.

(54) Title: PROCESS FOR THE PRODUCTION OF IMIDAZOPYRIDIN-8-ONES

(57) Abstract: The invention relates to a process for the production of 7-(trialkyl-silanytoxy)- 2,3-dimethyl-8-phenyl-8,9dihy-  
dro-7H-1,3a,9-triazacyclopenta[a]naphthalen-6-one and related compounds by using NBS as oxidizing agent.



WO 2004/087718 A1

10/550691  
JC20 Rec'd PCT/PTO 26 SEP 2009

- 1 -

## Process for the production of imidazopyridin-8-ones

### Field of application of the invention

The invention relates to a novel process, which is used in the pharmaceutical industry in the synthesis of intermediates for the production of medicaments.

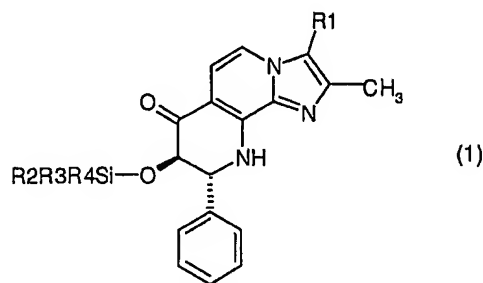
### Prior art

The international patent applications WO98/42707, WO01/72756, WO01/72757 and WO02/34749 disclose tricyclic imidazopyridine derivatives having a very specific substitution pattern, which are suited for the treatment of gastric and intestinal disorders. In said patent applications, reaction schemes are given in which the synthesis of the final products, starting from imidazopyridin-8-ones, is illustrated. These imidazopyridin-8-ones are described in more detail in international patent application WO01/72748. In several publications, such as Karmakar et al., Journal of the American Chemical Society 77, 55-69 (1955), Zechmeister et al., Journal of the American Chemical Society 75, 4493-4495 (1953) and Snyder et al., Journal of the American Chemical Society 71, 1395-1396 (1949) the use of N-bromosuccinimide in dehydrogenation processes is described.

### Description of the invention

The invention relates to a process, which is used for the preparation of important intermediates for the production of the compounds mentioned in the prior art, and further compounds having a similar basic structure.

The invention relates in a first aspect to a process for the production of compounds of formula 1,



in which

R1 is hydrogen, methyl or hydroxymethyl,

R2 is 1-7C-alkyl,

- 2 -

R3 is 1-7C-alkyl and

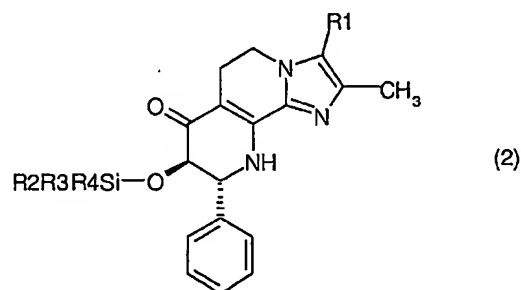
R4 is 1-7C-alkyl,  
and their salts.

1-7C-Alkyl represents straight-chain or branched alkyl radicals having 1 to 7 carbon atoms. Examples which may be mentioned are the heptyl radical, isoheptyl radical (5-methylhexyl radical), hexyl radical, isohexyl radical (4-methylpentyl radical), neohexyl radical (3,3-dimethylbutyl radical), pentyl radical, isopentyl radical (3-methylbutyl radical), neopentyl radical (2,2-dimethylpropyl radical), butyl radical, isobutyl radical, sec-butyl radical, tert-butyl radical, propyl radical, isopropyl radical, ethyl radical and the methyl radical.

Suitable salts of compounds of the formula 1 are especially all acid addition salts. Particular mention may be made of the salts of the inorganic and organic acids customarily used. Those which are suitable are water-soluble and water-insoluble acid addition salts with acids such as hydrochloric acid, hydrobromic acid, phosphoric acid, nitric acid, sulfuric acid, acetic acid, citric acid, D-gluconic acid, benzoic acid, 2-(4-hydroxybenzoyl)benzoic acid, butyric acid, sulfosalicylic acid, maleic acid, lauric acid, malic acid, fumaric acid, succinic acid, oxalic acid, tartaric acid, embonic acid, stearic acid, toluene-sulfonic acid, methanesulfonic acid or 3-hydroxy-2-naphthoic acid, where the acids are employed in salt preparation - depending on whether it is a mono- or polybasic acid and depending on which salt is desired - in an equimolar quantitative ratio or one differing there from.

It is known to the person skilled in the art that the compounds according to the invention and their salts, if they are isolated, for example, in crystalline form, can contain various amounts of solvents. The invention therefore also comprises all solvates and in particular all hydrates of the compounds of the formula 1, and also all solvates and in particular all hydrates of the salts of the compounds of the formula 1.

The process is characterized in that compounds of formula 2,



In which R1, R2, R3 and R4 have the meanings given above, are dehydrogenated (oxidized) with NBS (N-bromosuccinimide).

- 3 -

The dehydrogenation (oxidation) with NBS is carried out in an inert solvent, for example in a chlorinated hydrocarbon, such as carbon tetrachloride or dichloromethane, or in a ketone, e. g. acetone or butanone, or in an ether, e. g. tetrahydrofuran or dioxan, or in DMSO or in acetonitrile.

The reaction of NBS with a compound of formula 2 is conveniently effected at a temperature of  $-70^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ , preferably at a temperature of  $0^{\circ}\text{C}$  to  $+30^{\circ}\text{C}$ , and with the subsequent aid of a base, preferably with an organic base, such as an amine, e. g. diisopropylamine, methyl-diisopropylamine or, in particular, triethylamine. Advantageously, NBS is added to a solution of the compound of formula 2 in a first step, using an amount of 1,0 equivalents of NBS, with immediate subsequent start of the addition of the base.

Preferred compounds of formula 1, which are prepared by the process according to the invention, are those, in which

R1 is methyl,

R2 is 1-7C-alkyl,

R3 is 1-4C-alkyl and

R4 is 1-4C-alkyl,

and their salts.

Particularly preferred compounds of formula 1, which are prepared by the process according to the invention, are those, in which

R1 is methyl,

R2 is *tert*-butyl,

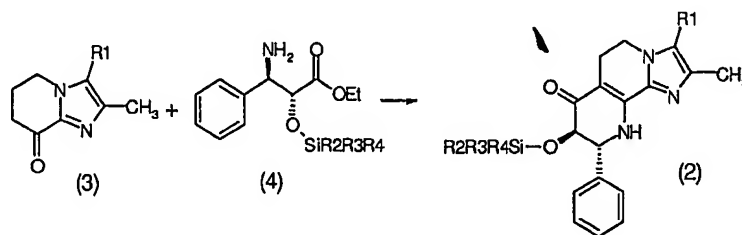
R3 is methyl and

R4 is methyl,

and their salts.

The starting compounds of formula 2 can be prepared, according to the following reaction scheme.

#### Scheme



- 4 -

The starting compound of formula (3) is known from WO01/72748. The silyl ether of formula (4) can be prepared according to methods known to the expert, for example by reacting phenylisoserine ethyl ester with *tert*-butyl-dimethylsilyl chloride under basic conditions. The reaction of (3) and (4) is preferably carried out in the presence of a suitable catalyst, for example *p*-toluenesulfonic acid, and under simultaneous removal of water. The initial formation of an intermediate imine is followed by a ring closure, which is performed by using a strong base, for example potassium *tert*-butoxide, lithium *tert*-butoxide, sodium bis(trimethylsilyl)amide or preferably lithium diisopropylamide.

The compounds of formula 1 are valuable intermediates for the synthesis of compounds as described in international patent applications WO98/42707 and WO01/72756. The 8-hydroxy-7-oxo-7,8,9,10-tetrahydroimidazo[1,2-*b*][1,7]naphthyridine, which is given for example in scheme 8 of international patent application WO98/42707 as intermediate, is obtained from compounds 1 by hydrolysis, for example with hydrochloric acid.

The following examples serve to illustrate the invention in greater detail without restricting it. Likewise, further compounds of the formula 1 whose preparation is not described explicitly can be prepared in an analogous manner or in a manner familiar *per se* to the person skilled in the art using customary process techniques. The abbreviation min stands for minute(s), h for hour(s) and RT for room temperature.

## Examples

### 1. t-Butyl-dimethyl-silylether of phenyl isoserine ethyl ester

1323 g (4.06 mole) of (R,R)-phenylisoserine ethyl ester are dissolved in 6.6 L of dichloromethane. To this solution, 397.4 g of imidazole and 724 g of t-butyldimethylsilyl chloride are added. The mixture is stirred for 16 h at RT. The reaction mixture is washed subsequently with 6 L and 4 L of water. The resulting clear dichloromethane layer is dried over sodium sulphate, filtered and concentrated under reduced pressure. The obtained 1509 g of the title compound are used as such in Example 2 without further purification.

### 2. 7-(t-Butyl-dimethyl-silanyloxy)-2,3-dimethyl-8-phenyl-5,7,8,9-tetrahydro-4H-1,3a,9-triazacyclopenta[a]naphthalen-6-one

To 1509 g of t-butyl-dimethyl-silylether of phenyl isoserine ethyl ester (obtained in Example 1), dissolved in 10.5 L of toluene, 14 g of p-toluenesulphonic acid monohydrate and 736 g of 2,3-dimethyl-6,7-dihydro-5H-imidazo[1,2-a]pyridin-8-one are added. The mixture is stirred and boiled under reflux until 80 mL of water are collected in the Dean-Stark trap used. The mixture is cooled to  $-15^{\circ}\text{C}$  and 6 L of THF are added. To this solution, 6 L of 2 M lithium-diisopropylamide (solution in THF/n-heptane) are added dropwise within 1 h. The mixture is stirred for 30 min. without external cooling (the temperature rises to  $-5^{\circ}\text{C}$ ) and then quenched with 7 L of aqueous ammonium chloride solution. The two layers are separated. The organic layer is dried over sodium sulphate and filtered. After removal of the solvents in vacuo, 1811 g of crude 7-(tert-butyl-dimethyl-silanyloxy)-2,3-dimethyl-8-phenyl-5,7,8,9-tetrahydro-4H-1,3a,9-triazacyclopenta[a]naphthalen-6-one are isolated. This material is dissolved in 3.9 L of boiling methanol and cooled to  $-5^{\circ}\text{C}$  while stirring. The formed precipitate is collected and rinsed with 1.75 L of cold methanol. After drying, 558 g of the title compound are obtained. The mother liquor is concentrated to 1.5 L and stirred at  $-5^{\circ}\text{C}$  for several hours. The precipitate is collected and rinsed with 0.25 L of methanol. Another portion of 96.5 g of the title compound are isolated. Total yield is 654.5 g (38.5%).

### 3. 7-(t-Butyl-dimethyl-silanyloxy)-2,3-dimethyl-8-phenyl-8,9-dihydro-7H-1,3a,9-triazacyclopenta[a]naphthalen-6-one

25 g (59.1 mmole) of 7-(tert-butyl-dimethyl-silanyloxy)-2,3-dimethyl-8-phenyl-5,7,8,9-tetrahydro-4H-1,3a,9-triazacyclopenta[a]naphthalen-6-one are suspended in 150 ml of acetonitrile. The mixture is stirred and cooled in a thermostated reactor at  $15^{\circ}\text{C}$ . A solution of 10.52 g (1 equivalent) of N-bromosuccinimide in 100 ml of acetonitrile is added in the course of 1 h while keeping the temperature at  $15^{\circ}\text{C}$ . When addition of N-bromosuccinimide is completed, 22.5 ml of triethylamine are added with further stirring at  $15^{\circ}\text{C}$  within the course of 45 min. Stirring is continued for additional 2 h at  $15^{\circ}\text{C}$ . After cooling the obtained suspension to  $10^{\circ}\text{C}$ , 138 ml of water are added slowly during 30 min. The sus-

- 6 -

pension is cooled to 5°C, stirred for further 30 min and then filtered. The yellow filter cake is washed twice with 125 ml of methanol/water 85:15 v/v and then dried. The title compound is obtained as a yellow solid.

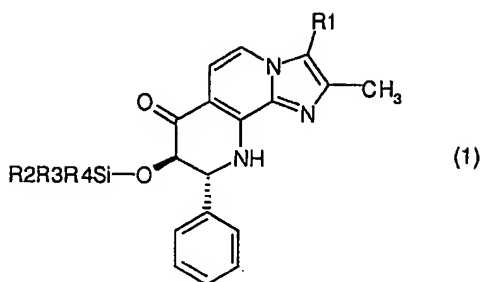
**4. 7-Hydroxy-2,3-dimethyl-8-phenyl-8,9-dihydro-7H-1,3a,9-triaza-cyclopenta[a]naphthalen-6-one**

386.5 g (0.916 mole) of 7-(t-butyl-dimethyl-silyloxy)-2,3-dimethyl-8-phenyl-8,9-dihydro-7H-1,3a,9-triaza-cyclopenta[a]naphthalen-6-one are suspended in 1.4 L of methanol and cooled on an ice/water bath to 10°C. Then 0.734 L of 30% aqueous hydrochloride solution are added. The suspension becomes clear and after a few seconds a new precipitate is formed. The resulting suspension is stirred for two hours. After addition of 1.1 L of 25% aqueous ammonia the basic suspension (pH=9.6) is stirred for 1 hour. The formed solid is collected and rinsed with 1.1 L water and dried. To remove remaining silyl starting material, the solid is rinsed with 1 L of diethyl ether and dried again. 273.5 g of the title compound are obtained.

- 7 -

Claims

1. Process for the production of compounds of formula 1,



in which

R<sub>1</sub> is hydrogen, methyl or hydroxymethyl,

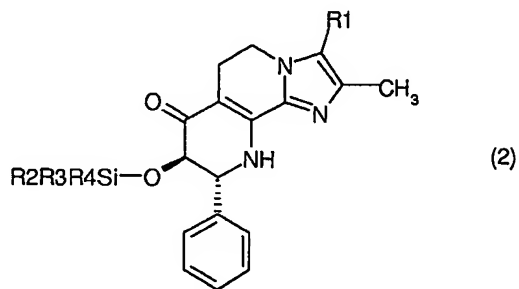
R<sub>2</sub> is 1-7C-alkyl,

R<sub>3</sub> is 1-7C-alkyl and

R<sub>4</sub> is 1-7C-alkyl,

and their salts,

which comprises dehydrogenating (oxidizing) compounds of formula 2,



in which R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub> and R<sub>4</sub> have the meanings given above, by using NBS (N-bromosuccinimide).

2. Process as claimed in claim 1, for the production of compounds of formula 1, in which

R<sub>1</sub> is methyl,

R<sub>2</sub> is bromine,

R<sub>3</sub> is 1-7C-alkyl,

R<sub>4</sub> is 1-4C-alkyl and

R<sub>4</sub> is 1-4C-alkyl.

- 8 -

3. Process as claimed in claim 1, for the production of compounds of formula 1, in which  
R1 is methyl,  
R2 is bromine,  
R2 is tert-butyl,  
R3 is methyl and  
R4 is methyl.
4. Process as claimed in claim 1, characterized in that the amount of NBS used is approximately 1 equivalent, calculated on the basis of the amount of the compound of formula 2 used.
5. Process as claimed in claim 1, characterized in that subsequent to the reaction with NBS an organic base is used for the removal of HBr.
6. Process as claimed in claim 1, characterized in that subsequent to the reaction with NBS an organic amine is used for the removal of HBr.
7. Process as claimed in claim 1, characterized in that subsequent to the reaction with NBS triethylamine is used for the removal of HBr.
8. Process as claimed in claim 1, characterized in that the reaction is effected at a temperature of -70°C to +50°C.
9. Process as claimed in claim 1, characterized in that the reaction is effected at a temperature of 0°C to +30°C.
10. Process as claimed in claim 1, characterized in that the reaction is effected in an inert organic solvent.

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP2004/050414

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07F7/18 C07D471/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07F C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BEILSTEIN Data, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 02/34749 A (BYK GULDEN LOMBERG CHEMISCHE FABRIK GMBH) 2 May 2002 (2002-05-02) page 58, line 1 - line 11	1-10
Y	WO 01/72757 A (BYK GULDEN LOMBERG CHEMISCHE FABRIK GMBH) 4 October 2001 (2001-10-04) page 18, line 1 - line 10 * page 11, scheme 2 *	1-10

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \* & \* document member of the same patent family

Date of the actual completion of the international search

25 August 2004

Date of mailing of the international search report

06/09/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Elliott, A

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KARMAKAR G ET AL: "On some dehydrogenation products of alpha-carotene, beta-carotene and cryptoxanthin" JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, vol. 77, no. 1, 5 January 1955 (1955-01-05), pages 55-60, XP002239511 ISSN: 0002-7863 the whole document	1-10
Y	----- ZECHMEISTER L ET AL: "Action of N-bromosuccinimide on beta-carotene" JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, vol. 75, no. 18, 20 September 1953 (1953-09-20), pages 4493-4495, XP002239512 ISSN: 0002-7863 the whole document	1-10
Y	----- SNYDER H R ET AL: "1-Cyano-1,3-butadiene. III. The dimer of 1-cyano-1,3-butadiene" JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, vol. 71, no. 4, 19 April 1949 (1949-04-19), pages 1395-1396, XP002239513 ISSN: 0002-7863 the whole document	1-10
	-----	

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0234749	A	02-05-2002	AU 1056302 A	06-05-2002
			BR 0114873 A	01-07-2003
			CA 2426616 A1	02-05-2002
			WO 0234749 A1	02-05-2002
			EP 1332143 A1	06-08-2003
			HU 0302308 A2	28-11-2003
			JP 2004512338 T	22-04-2004
			NO 20031830 A	24-04-2003
			SK 5072003 A3	11-09-2003
			US 2004106642 A1	03-06-2004
WO 0172757	A	04-10-2001	AU 5475601 A	08-10-2001
			BR 0109512 A	17-12-2002
			CA 2404477 A1	04-10-2001
			CN 1420890 T	28-05-2003
			WO 0172757 A1	04-10-2001
			EP 1303519 A1	23-04-2003
			JP 2003528879 T	30-09-2003
			US 2003139412 A1	24-07-2003